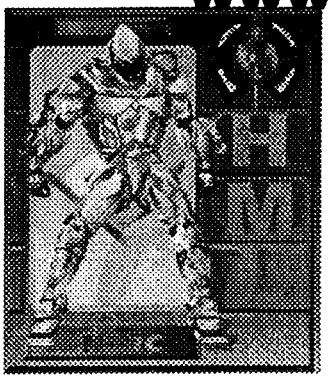
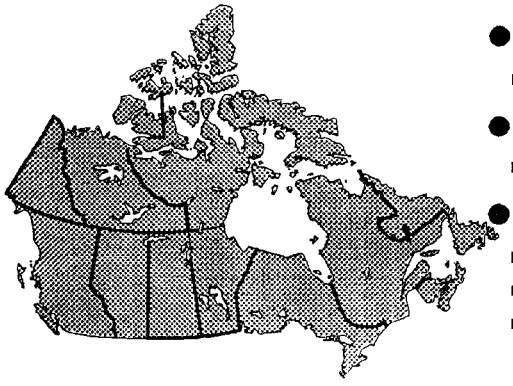
Canadian National Calibration Reference Centre for Bioassay and *In Vivo* Monitoring

www.hc-sc.gc.ca/ncrc



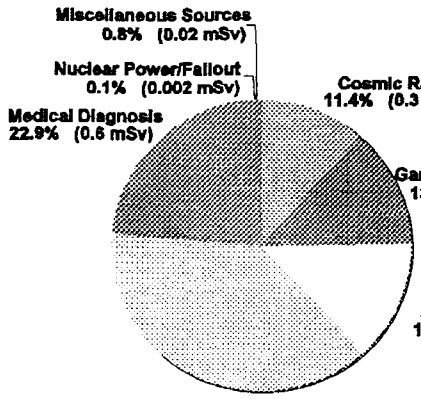
Human Monitoring Laboratory

CANADA



- **Large country:**
  - 9,976,140 km^2 (world's second).
- **Population:**
  - ~31,000,000 (3.1 persons/km^2)
- **Government**
  - Federal (1)
  - Provincial Government (10)
  - Territorial Government (3)

ANNUAL DOSES TO CANADIANS



NORM

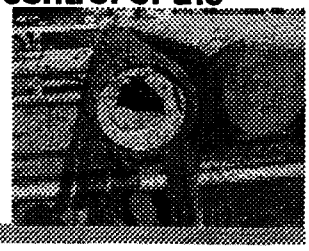
NORM

NORM

NORM

WHAT is NORM?

- NORM = Naturally Occurring Radioactive Materials
- Radioactive elements of interest include elements in the uranium and thorium decay series and potassium.
- Source material is not a part of the nuclear fuel cycle and therefore does NOT come under the control of the Canadian Nuclear Safety Commission.



WHERE IS NORM?

- **Mineral Extraction & Processing.**
  - Phosphate fertiliser (U/Ra), abrasives, and refractory industries (Th).
- **Oil & Gas Production.**
  - ^{226}Ra & ^{210}Pb.
- **Metal Recycling.**
  - ^{226}Ra in drill pipes.
- **Thermal-Electric Production.**
  - U, Ra & Th in coal fly ash.
- **Water and Water Treatment Facilities.**
  - Up to ~800 µg/L uranium in well water.
  - Rn in fish hatcheries.
- **Tunnelling and Underground Workings.**
  - Rn in caverns, sewers, electrical vaults, tunnels.

5

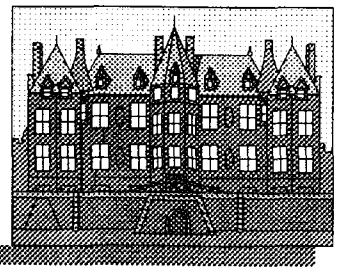
AIRCREW

- **Air Crew subject to Canada Labour Code and Aviation Occupational Safety Regulations.**
- **None of these regulations specifically deal with radiation exposure.**
- **Dept of Human Resources Development Canada (HRDC) administers Labour Code.**
- **HRDC has delegated enforcement (w.r.t. air crew) to Transport Canada.**

6

REGULATION

- **NORM is not part of the nuclear fuel cycle.**
  - NFC regulated by Canadian Nuclear Safety Commission.
  - Medical X-rays regulated by Provincial Governments.
  - Other X-rays regulated by Federal Government (Health Canada).
- **NORM is a Provincial - Territorial issue.**
  - For example, transporting NORM involves:
    - Provincial - Territorial Health, Labour, and Radiation Regulatory Agencies for worker and public exposure
    - Provincial - Territorial Environment Regulatory Agencies for disposal.

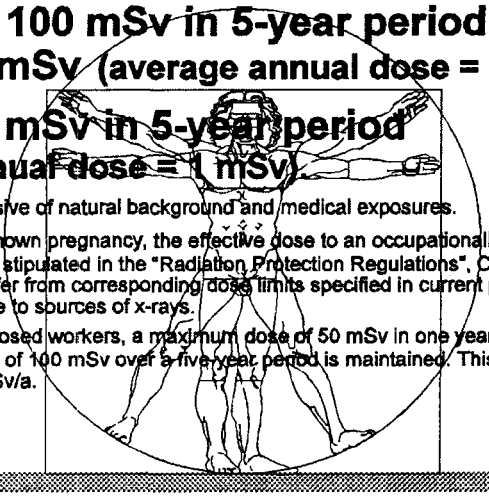


BASIC PRINCIPLES

- **Persons exposed to NORM should be subject to the same radiation exposure standards that apply to persons exposed to CNSC-regulated radioactive materials.**
- **Ensure adequate control of NORM encountered by affected industries.**
- **Harmonize standards.**
- **Reduce jurisdictional gaps or overlap.**

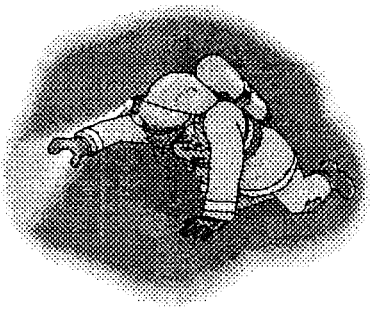
RADIATIONDOSELIMITS

- **WORKER: 100 mSv in 5-year period with yearly max of 50 mSv (average annual dose = 20 mSv) .**
- **PUBLIC: 5 mSv in 5-year period (average annual dose = 1 mSv).**
  - These limits are exclusive of natural background and medical exposures.
  - For the balance of a known pregnancy, the effective dose to an occupationally exposed worker must be limited to 4 mSv as stipulated in the "Radiation Protection Regulations", Canadian Nuclear Safety Act. This limit may differ from corresponding dose limits specified in current provincial legislation applicable for exposure to sources of x-rays.
  - For occupationally exposed workers, a maximum dose of 50 mSv in one year is allowed, provided that the total effective dose of 100 mSv over a five-year period is maintained. This translates into an average limit of 20 mSv/a.



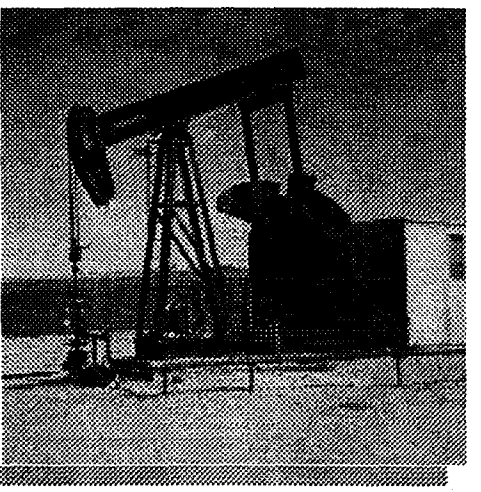
WHATSOUTHERE?

- **Scale**
  - Radium (226/228). Median: 17.8 kBq/kg, 75th percentile: 99.9 kBq/kg
  - Pb-210. Median: 13.3 kBq.kg, 75th percentile: 74.9 kBq/kg
- **Sludge**
  - Radium (226/228). Median: 2.8 kBq/kg
  - Pb-210. Median: 2.1 kBq.kg
- **External fields (on contact)**
  - Oil production equipment: 20 to 2,450 nGy/h
    - 1250 to 409 days to reach 1 mSv
  - Gas processing equipment: 20 to 760 nGy/h



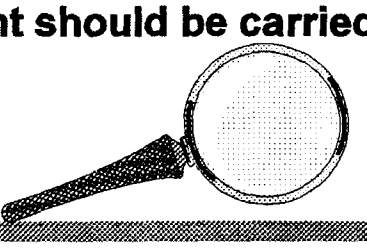
NORM clasifications thresholds

- **Investigation Threshold**
  - incremental dose of 0.3 mSv/a
- **Dose Management Threshold**
  - assessed incremental dose greater than 1 mSv/a
- **Radiation Protection Management Threshold**
  - assessed or measured incremental dose of 5 mSv/a or greater

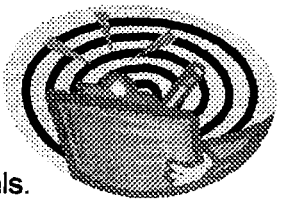


INITIAL REVIEW

- **If a workplace:**
  - falls in one of the NORM-prone industries
  - stores, handles or disposes of materials containing amounts of natural radioactive substances in excess of amounts for diffuse or discrete NORM
  - has suspected incremental effective dose rates in excess of 0.3 mSv/a
- **Then, a dose assessment should be carried out.**



CLASSIFICATION



- **Unrestricted:**
  - public < 0.3 mSv/a
  - worker < 1.0 mSva
  - No further action is needed to control doses or materials.
- **NORM Management:**
  - public > 0.3 mSv/a; worker < 1.0 mSva
  - Introduction of incidentally exposed worker access restrictions.
  - Introduction of shipping and/or material management.
  - Changes in work practices.

CLASSIFICATION cont

- **Dose Management**
  - Worker > 1.0 mSv/a
  - Worker notification of radiation sources.
  - Consideration of work procedures and protective clothing to limit worker dose from NORM.
  - Application of engineering controls where appropriate.
  - Training to control and reduce worker dose.
  - Introduction of a worker radiation dose estimate program. Doses may be estimated from the dose rate in each working area and the time spent in each area or by personal monitoring.
  - Reporting of worker doses to the National Dose Registry (NDR)

CLASSIFICATION cont

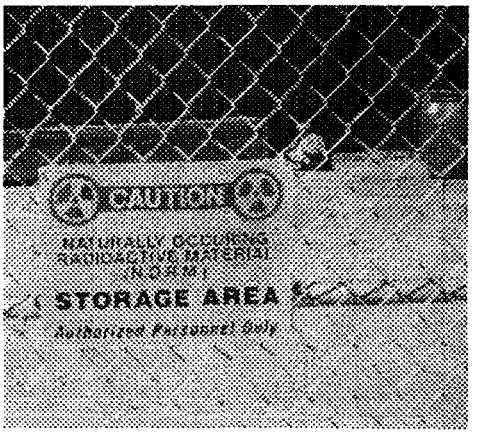
- **Radiation Protection Management - 1**
  - Worker > 5.0 mSv/a
  - Estimated annual effective dose to an occupationally exposed worker is greater than 5 mSv/a
    - Introduce a formal radiation protection program. This program is similar to the formal program required by the CNSC for nuclear energy workers exceeding 5 mSv/a.
    - Place those workers estimated to exceed 5 mSv/a in a personal radiation dosimetry program meeting the requirements of S-106, Technical and Quality Assurance Standards for Dosimetry Services in Canada.
    - Provide protective equipment, clothing and work procedures to reduce worker dose and the spread of contamination.

CLASSIFICATION cont

- **Radiation Protection Management - 2**
  - Worker > 5.0 mSv/a
  - Measured annual effective dose reported by personal radiation dosimetry program is greater than 5 mSv/a
    - Use engineering controls and provide protective equipment designed to reduce worker dose as required.
    - Ensure that workers do not exceed the five-year average occupational dose limit of 20 mSv/a.

NORM Derived Working Limits

- **Incremental Dose Rate above off-site background**
- **Gamma Radiation Dose Rate**
  - Investigation Threshold - 0.15 µSv/h (0.3 mSv/a)
  - Dose Management Threshold - 0.5 µSv/h (1.0 mSv/a)



RADON CLASSIFICATION

ANNUAL DOSE	NORM PROGRAM CLASSIFICATION
3000 Bq/m³ (20 mSv/a Occupational Dose Limit; five year Avg.)[a]	RADIATION PROTECTION MANAGEMENT
800 Bq/m³ (6 mSv Radiation Protection Management DWL)[a]	NORM MANAGEMENT
150 Bq/m³ (Investigation DWL)[c]	UNRESTRICTED
Background	

WORKERS

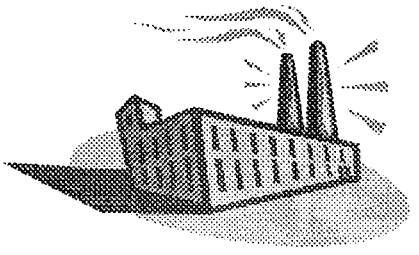
- **Occupationally Exposed Workers**
  - employees who are exposed to NORM sources of radiation through their regular duties. They are classified as NORM Workers working in an occupational exposure environment, and their average annual effective dose must not exceed 20 mSv.
- **Incidentally Exposed Workers**
  - employees whose regular duties do not include exposure to NORM sources of radiation. They are considered as members of the public who work in an occupational exposure environment and, as such, the annual effective dose limit for these workers is 1 mSv.

INHALATION CONTROL MEASURES

- **Inhalation can deliver most of the dose in some NORM work environments. Where annual intakes exceed 1/20 of the ALI, engineering control of the source of airborne radioactive material is the preferred management method.**
- **If intakes exceed 25% of the ALI (equivalent to 5 mSv/a) after engineering controls are applied, a respiratory protection program and/or limiting worker access should be considered as part of the radiation protection program.**

DERIVED RELEASE LIMITS

- **Unrestricted Classification**
  - The Guidelines recommend that NORM may be released with no radiological restrictions when the associated dose is no more than 0.3 mSv in a year.
- **Diffuse NORM**
  - large in volume
  - low radioactive concentration
  - uniformly dispersed throughout the material



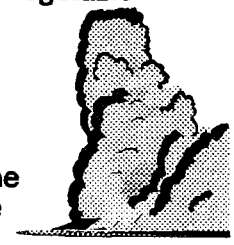
- **Discrete NORM**
  - small in size
  - exceed the concentration criteria for a diffuse source
- **Surface Contamination**

DIFFUSE NORM

NORM RADIONUCLIDE	Derived Release Limit [a]		
	AQUEOUS [b] (Bq/L)	SOLID (Bq/kg)	AIR (Bq/m^3)
Uranium-238 Series (all progeny:)	1	300	0.003
Uranium-238 (U-238, Th-234,Pa-234m, U-234)	10	10,000	0.05
Thorium-230	5	10,000	0.01
Radium-226 (in equilibrium with its progeny)	5	300	0.05
Lead-210 (in equilibrium with bismuth-210 and polonium-210)	1	300	0.05
Thorium-232 Series (all progeny)	1	300	0.002
Thorium-232	1	10,000	0.006
Radium-228 (in equilibrium with Ac-228)	5	300	0.005
Thorium-228 (in equilibrium with all its progeny)	1	300	0.003
Potassium-40	n/a [b]	17,000	n/a

DIFFUSE NORM

- **Assumptions**
  - All radionuclides and compartments in equilibrium
  - Typical values for uptake and transfer factors
  - No allowance for hold-up time
  - 25% "occupancy" factor for solid source (groundshine, soil ingestion, resuspension), 25% 'occupancy' factor for air, and 50% of vegetable intake grown on soil
  - No correction for shielding, surface roughness
- **Aqueous Release limits.**
  - ~10x Guidelines for Canadian Drinking Water Quality.
  - Subsequent dilution of the release is assumed. Refer to the Provincial Drinking Water Standard where planned diffuse NORM releases must meet provincial drinking water standards.



DISCRETE NORM

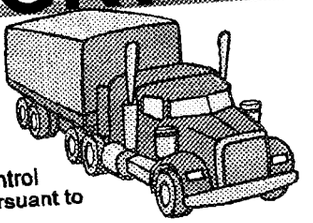
NORM RADIONUCLIDE	Unconditional Derived Release Limit[a] (Bq)
Uranium Ore (in equilibrium with all progeny)	1,000
Uranium-238 (partitioned) (in equilibrium with thorium-234 and protactinium-234)	10,000
Thorium-230 (no progeny)	10,000
Radium-226 (in equilibrium with its progeny)	10,000
Lead-210 (in equilibrium with bismuth-210 and polonium-210)	10,000
Thorium-232 (in equilibrium with all progeny)	1,000
Radium-228 (in equilibrium with actinium-228)	100,000
Thorium-228 (in equilibrium with its short-lived progeny)	10,000
Potassium-40	1,000,000

DISCRETE NORM

[redacted]

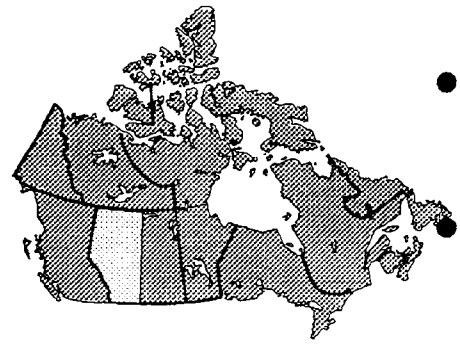
- Dose rate < 0.5 μSv/h at 50 cm.
- Surface Contamination: 1Bq/cm ^{2} averaged over 100 cm ^{2}

NORM TRANSPORT



- **Unrestricted NORM Shipments**
  - General exclusion: Material has a total specific activity less than or equal to 70 Bq/g and,
  - CNSC exemption: there are no regulatory requirements for its possession or use under the Nuclear Safety and Control Act, and the Packaging and Transportation Regulations pursuant to that Act and,
  - Meets the Unconditional Derived Release Limits of the Canadian NORM Guidelines.
- **NORM Shipments Subject to the Canadian Guidelines**
  - Ensure that the transport manifest contains the descriptor "Naturally Occurring Radioactive Material -NORM".
  - Ensure that the consignment is securely packaged in a manner that effectively prevents release of any NORM contamination during transport.
  - Do not affix radioactive placards or labels on the transport vehicle or on the exterior surfaces of the packaging.

NOWHAT?



- Guidelines are purely voluntary.
- Industry is paying some attention to the problem as some workers are concerned.
- Alberta is the only Province planning to legislate.